

OVERVIEW OF NBSA MODELS DEVELOPED BY CPG

November 8, 2017



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MODELS UNDER REVIEW

- Hydrodynamic and Sediment Transport Model
- Organic Carbon Model
- Contaminant Fate and Transport Model
- Bioaccumulation or Food Web Model

HYDRODYNAMIC AND SEDIMENT TRANSPORT MODEL (HST)

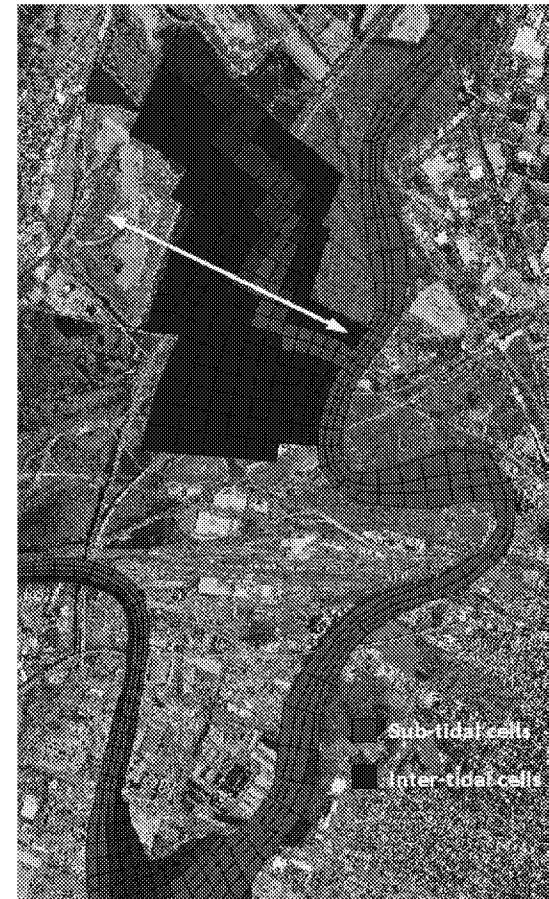
- EPA's HST comments – mainly text clarifications & limited technical issues
 - Navigation scour – CPG approach accepted
 - Time variable grain stress partitioning – CPG approach accepted
 - Initialization of grain stress parameters – problem in limited local areas - corrected
 - Calibration for Newark Bay – addressed
- Updates to models since the Draft RI
 - Timing of tidal exchange with Hackensack – Meadowlands
 - Modifications to address calibration in Newark Bay
 - Status of review

CPG'S SYSTEM UNDERSTANDING - HYDRODYNAMICS

- Tidal Prism
- Residual Currents
- Salinity Distributions (variations in stratification along bay)
- Circulation patterns – timing of tidal elevation changes
- Modifications to grid representation in Meadowlands
 - Still Approximate, but improved timing of tidal stage

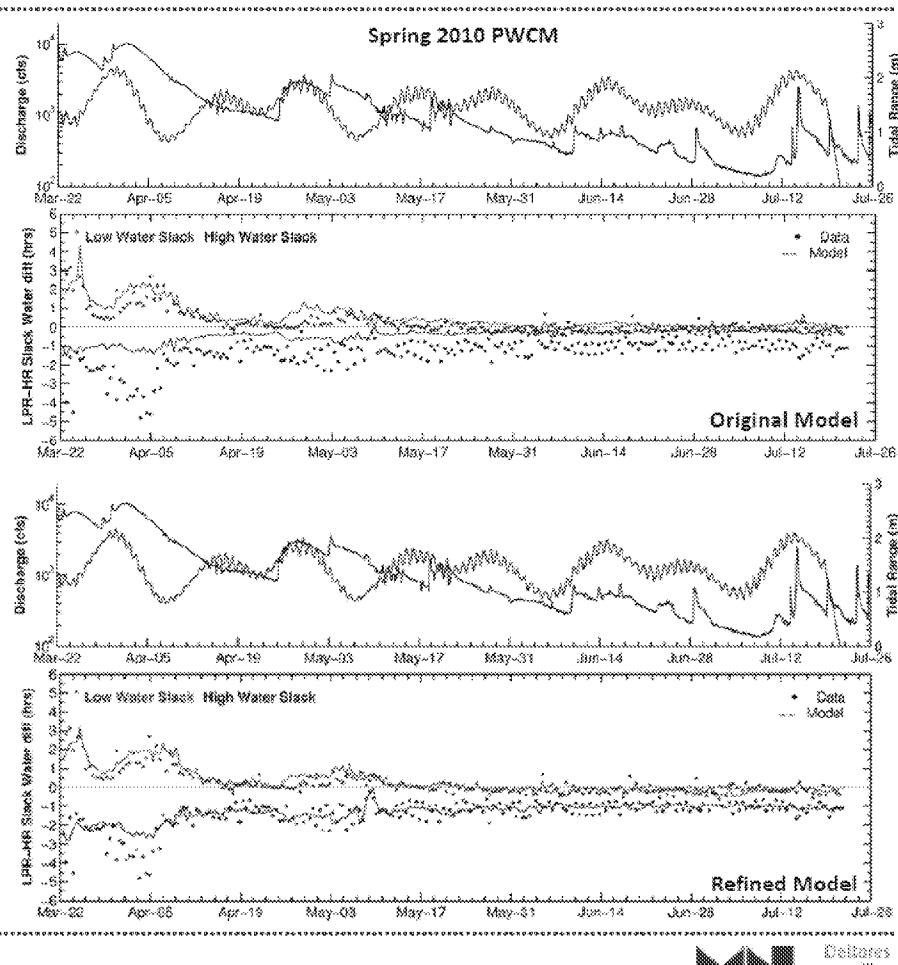
Model Geometry and Bathymetry Refinement – Meadowlands

- Precise data on the geographical extent of inter-tidal areas lacking
 - For example, tide gates present in some creeks in the Meadowlands
 - Implies wetlands upstream may be non-tidal
- Bathymetry in wetlands lacking
- NBSA model only needs to consider the Hackensack River as a boundary condition
 - Processes within the Meadowlands beyond scope of NBSA study
- Model refinements
 - Stretched existing portion of grid in Meadowlands by 2X
 - Change only to cell area, i.e., in model-space
 - Configured as a inter-tidal area drained by a creek
 - Bathymetry of inter-tidal areas set at MSL
 - Wetting and drying every tidal cycle
 - Increase bottom friction in Hackensack and Meadowlands
- Model refinements an approximation to reproduce correct exchange between Hackensack and NBSA



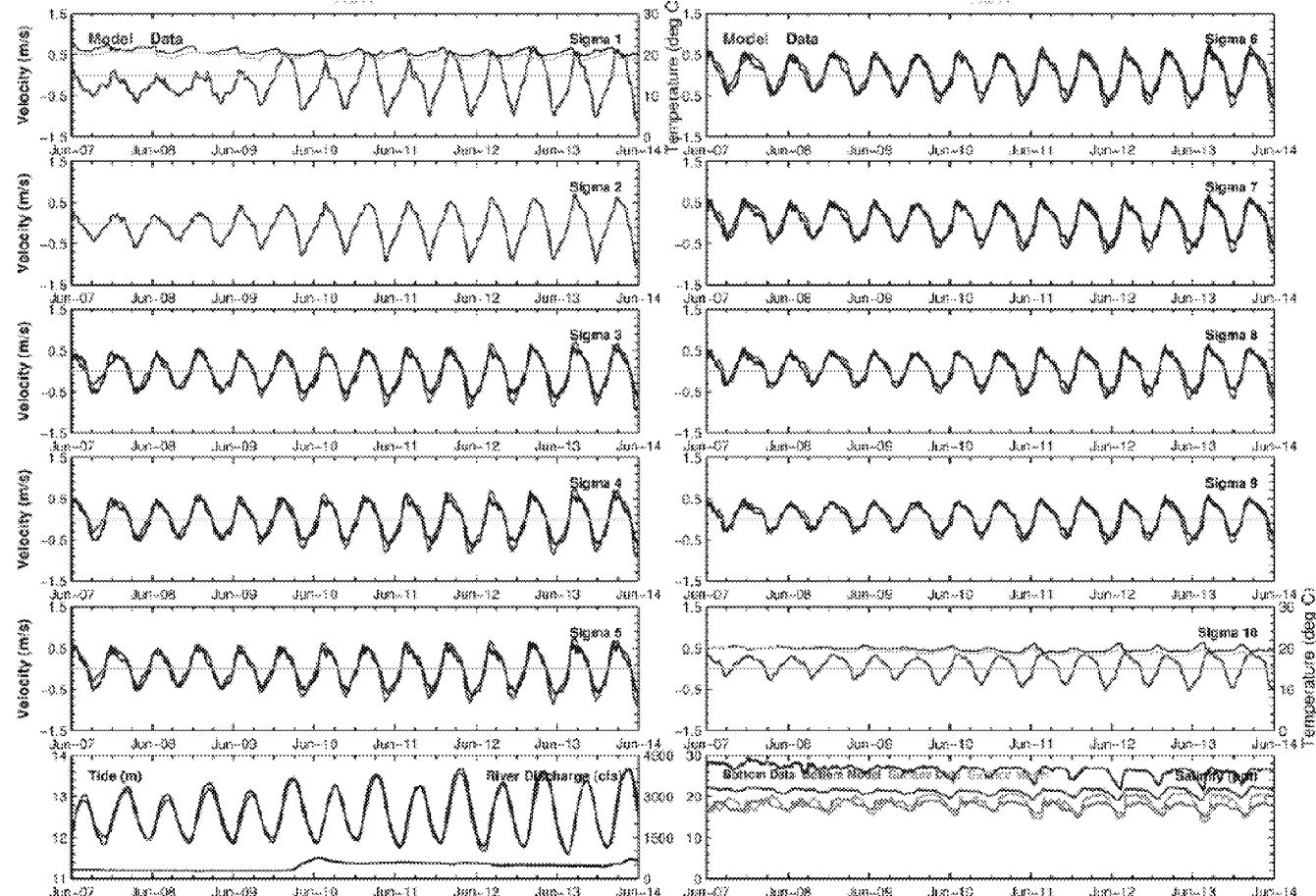
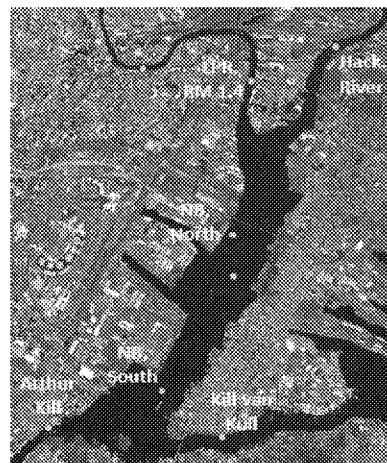
Refined Model Performance – Northern NB (Contd.)

- Refined model slightly better on LWS timing difference
- Refined model significantly better on HWS timing difference
- Refined model reproduces the exchange dynamics between NBSA and Hackensack River
- Similar results for Sommerfield and Chant



Refined Model Performance – Currents and Salinity, Newark Bay North

- Spring 2010 PWCM
- Minor discrepancies in some layers
 - Likely due to differences in tide
- When tide is similar in model and data, currents also similar



Refined Model Performance – Currents and Salinity, Full Time-Series Plots

- Spring 2010 PWCM
 - Kill van Kull
 - Arthur Kill
 - LPR RM 1.4
 - Hackensack River
 - Newark Bay, North
 - Newark Bay, South
- Sommerfield and Chant, Deployment 1
 - Kill van Kull
 - Arthur Kill
 - LPR RM 1.4
 - Hackensack River
 - Newark Bay, Channel
- Sommerfield and Chant, Deployment 2
 - Kill van Kull
 - Arthur Kill
 - LPR RM 1.4
 - Hackensack River
 - Newark Bay, Channel

NBSA Hydrodynamic Model Summary

- Hydrodynamic model performance assessed against conventional metrics (currents, temperature, salinity) and additional metrics quantifying the circulation patterns in Northern and Southern NBSA
- Model refinements limited to areas outside NBSA
 - Hackensack River and Meadowlands
 - Portions of Arthur Kill outside NBSA
- Refined model performs better against various metrics
 - Location artifacts at several stations limit representativeness of data, especially for Spring 2010 PWCM
 - Also has some impact on sediment transport model performance

CPG WAVE MODEL PRESENTATION

- Problems with wave data
- Theoretical expectations (Shore Protection Manual, 1984 – linear wave theory)
- SWAN Model predictions
- Linkage SWAN – ECOMSEDZLJS
 - Wave parameters at 1 hour intervals
 - Calculation of grain stress in ECOMSEDZLSJ
- Evaluation
 - Grain stress vs wind speed and direction
 - Bed composition (%sand) in areas with different grain stresses (wind and currents)

NBSA Sediment Transport Model Refinements

LPR/NB Modeling Program



Progress Meeting with EPA

March 29, 2010

Mahwah, NJ

Overview of Presentation

- Major datasets for model development and calibration
- Data review, issues, and limitations
- NBSA sediment transport system understanding
- NBSA sediment transport model refinements
- Calibration process and parameters
- Calibration performance

CPG'S SYSTEM UNDERSTANDING – SEDIMENT TRANSPORT

- Analyses
 - Hydrodynamic forcing relevant for sediment transport
 - System behavior over various time scales (SSC and fluxes)
 - Additional forcing relevant for sediment transport (wind-waves, navigation scour)
- TSS - Tidal time-scales
- TSS - Inter-tidal time-scales, and flow
- TSS – Vertical gradients
- Suspended sediment fluxes
- Sedimentation, maintenance dredging rate
- Navigation Impacts
- Wind-waves

System Understanding – Summary

- Based on net sediment fluxes
 - Import of sediments through Kill van Kull and export through Arthur Kill
 - * Flood-dominance in tidal currents in Kill van Kull
 - * Ebb-dominance in tidal currents in Arthur Kill
 - * Net counter-clockwise circulation around Staten Island
 - Hackensack River a net sink of sediments
 - Correlation of net solids fluxes with tidal range
 - * Positive correlation at LPR RM 1.4 (at low flows), Arthur Kill, Kill van Kull
 - ✓ Deep channels with little lateral (intra-tidal) storage
 - ✓ Increasing import of sediments with increasing tidal range at Kill van Kull and LPR RM 1.4
 - Due to flood-dominance in tidal currents
 - ✓ Decreasing export of sediments with increasing tidal range at Arthur Kill
 - Due to ebb-dominance in tidal currents
 - Net counter-clockwise circulation around Staten Island
 - * Negative correlation at NB channel stations (NBN in PWCM), and Hackensack
 - ✓ Deep channels with large lateral storage
 - Potentially, export and deposition of solids from channel to shallows during low energy conditions (neap-medium tides)
 - Potentially, erosion on shallows during high-energy conditions (spring tides, waves), and export from shallows to channel

System Understanding – Summary (Contd.)

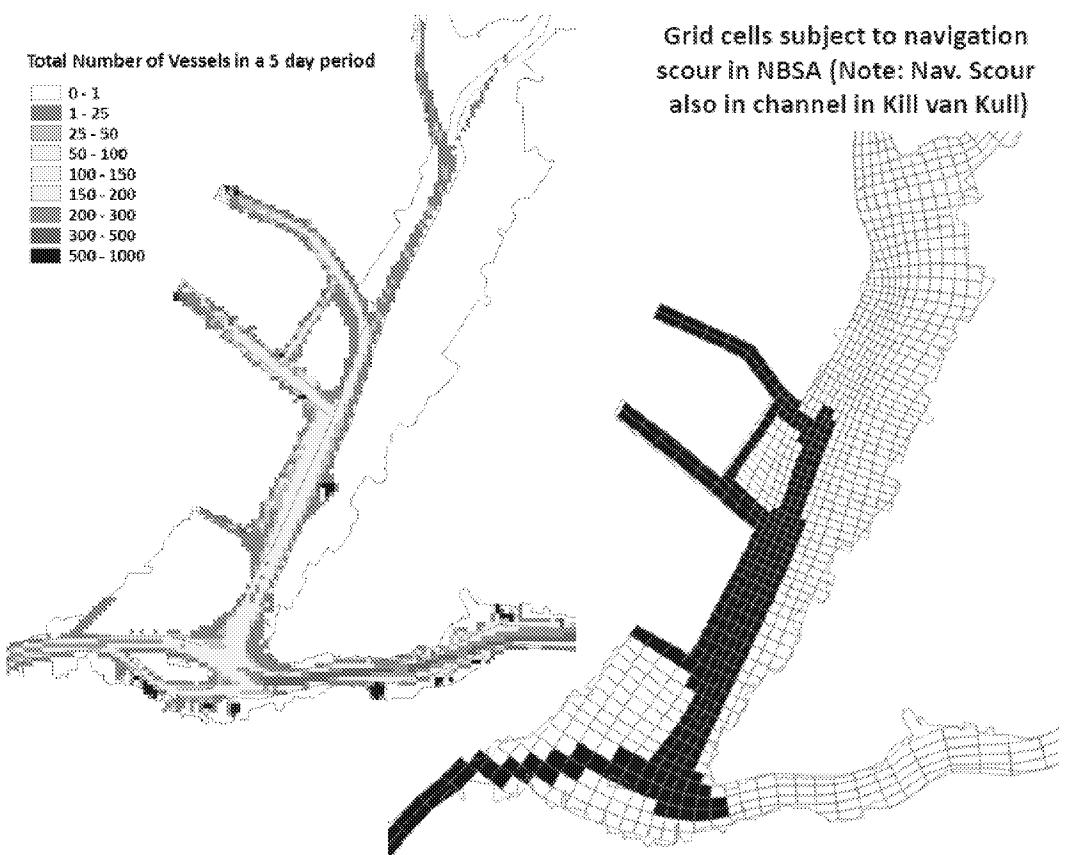
- Longitudinal, lateral, and vertical concentration patterns within NBSA
 - Longitudinal TSS gradients within NBSA (within the channel)
 - * Depth-average concentrations increase from Kills to NB North
 - * Depth-average concentrations decrease from NB North to LPR and Hackensack
 - * Spring-neap variability in concentrations driven by same variability in currents
 - Lateral TSS gradients
 - * Lower TSS (depth-average) on the shallows than the channel
 - Spatial pattern in vertical TSS gradients
 - * Largest vertical gradient within the channel in northern NB
 - * Vertically uniform TSS on the shallows
- Navigation scour potentially an important processes both locally as well as for far-field transport of sediments
- Wind-wave impacts restricted to the shallows in NBSA, likely a somewhat minor process

NBSA Sediment Transport Model Development

- Model inputs
 - Boundary conditions
 - Particle size classes and diameters
 - Settling velocity
- Global inputs/parameters; same as LPRSA model application
- Model refinements in NBSA
 - Bed erosion properties, multi-layer model
 - Initial conditions (parent layers, thickness on order of cm) defined based on Sedflume
 - Fluff layer (surficial layer, thickness on order of 1-2 mm) defined based on LPR parameterization
 - Aggrading layers (deposited layers) parameterized to reproduce initial conditions
 - Bed grain size distribution
 - Bed dry density
 - Navigation scour

Model Refinement – Navigation Scour

- Navigation scour implemented as a parameterized process in ST model
- Model inputs include
 - Locations of scour
 - Constant scour rate
- Scour performance
 - Scour only into deposited layers
 - Scoured sediment uniformly distributed in water column
- Navigation scour rate used as a calibration parameter to reproduce TSS and maintenance dredging rate

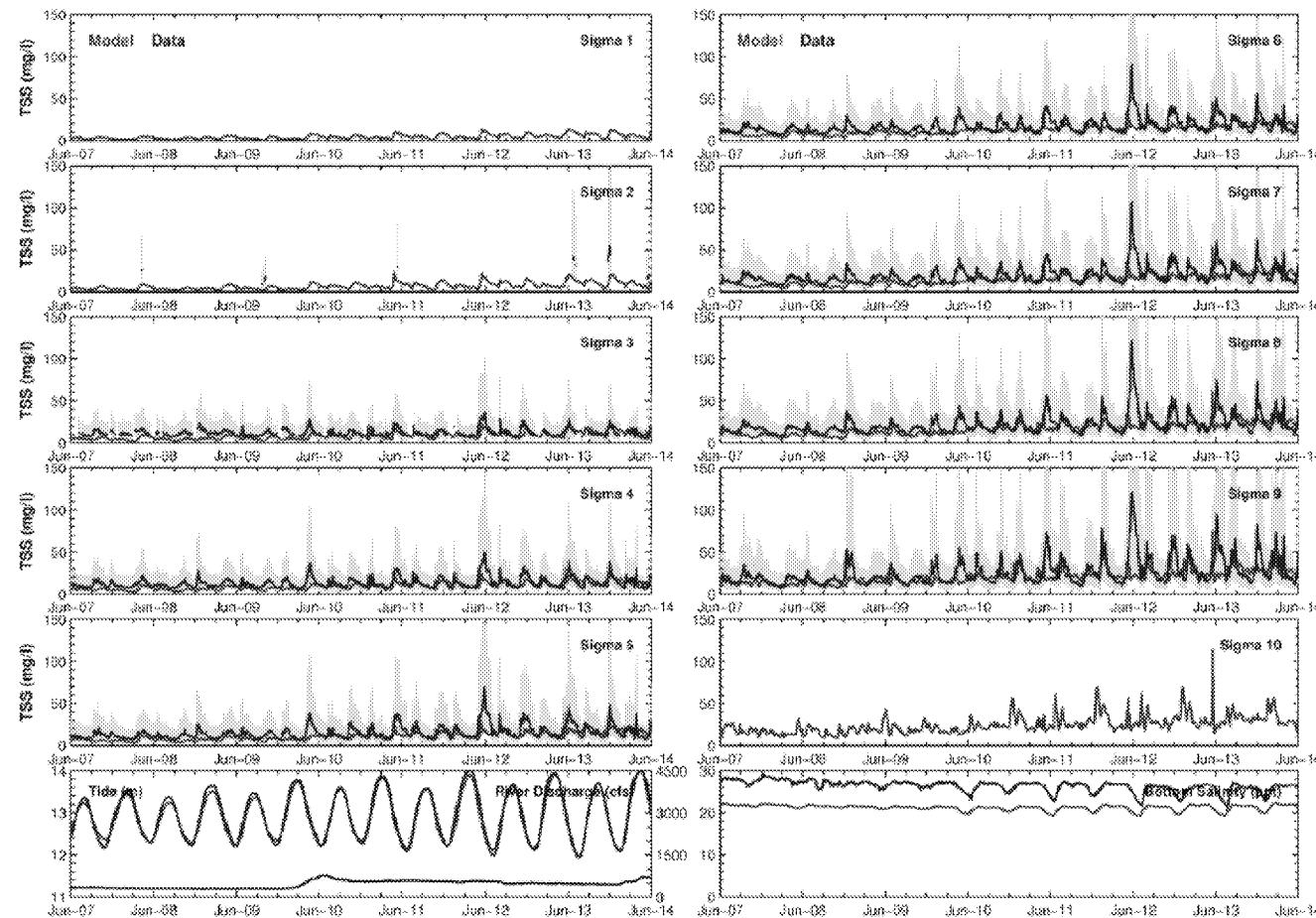


NBSA Model Calibration Process

- Calibration metrics
 - TSS
 - Spring 2010 PWCM
 - CWCM
 - Suspended sediment fluxes
 - Spring 2010 PWCM
 - Maintenance dredging records
- Calibration parameters
 - Navigation scour rate
 - Settling velocity of clays from Kills
 - Marine clays, about 15% of boundary loadings
 - Scale from Clay1 proportional to Silt2/Silt1
 - Assuming similar impacts of flocculation on Clay2 and Silt2 relative to Clay1 and Silt1 (from Stokes Law)

Solids Class	Settling Velocity – LPR draft (RI) Model	Settling Velocity – Combined LPRSA+NBSA Model
Clay 1 (river loadings)	0.05 mm/s	0.05 mm/s
Silt 1 (river loadings)	0.25 mm/s	0.25 mm/s
Clay 2 (marine loadings)	0.4 mm/s	0.08 mm/s
Silt 2 (marine loadings)	0.4 mm/s	0.4 mm/s

NBSA Model Performance – NB North, TSS, PWCM Data

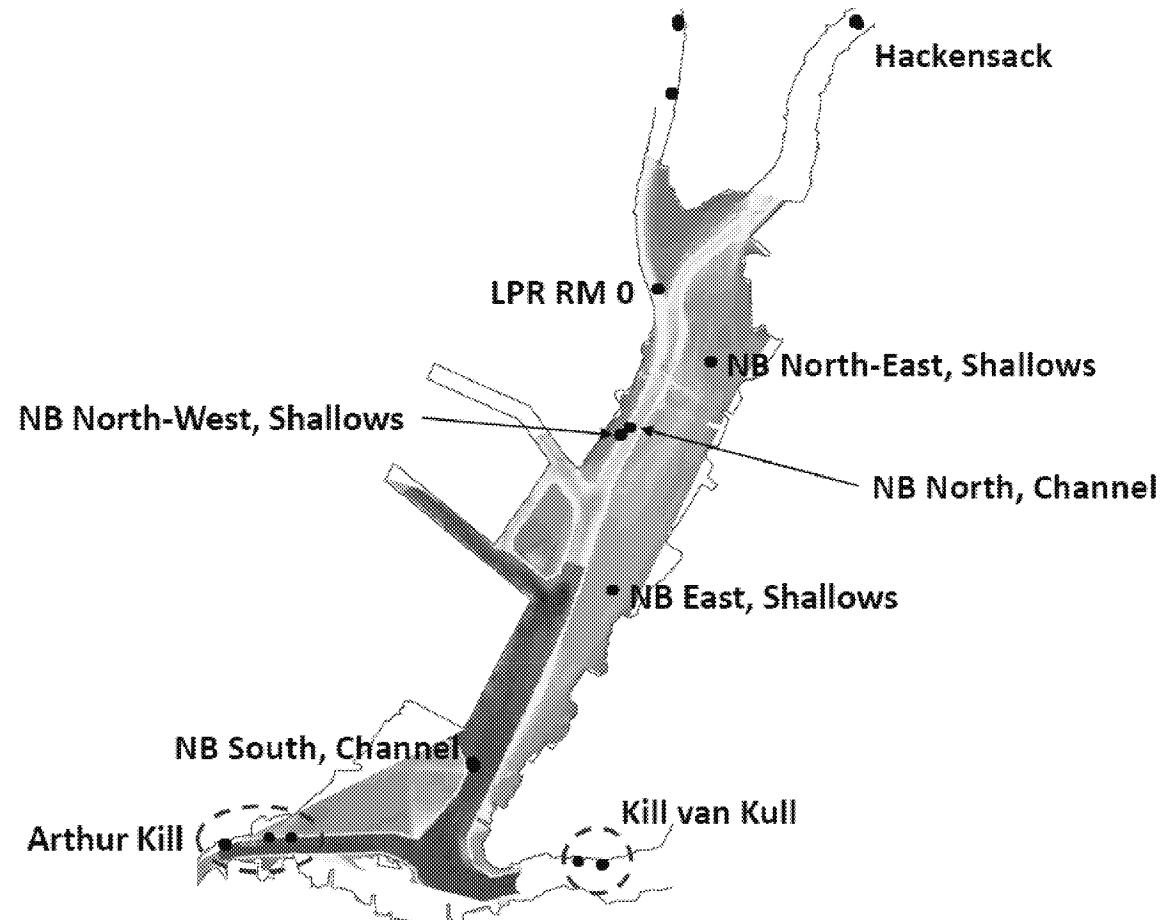


LPR/NB Modeling Program

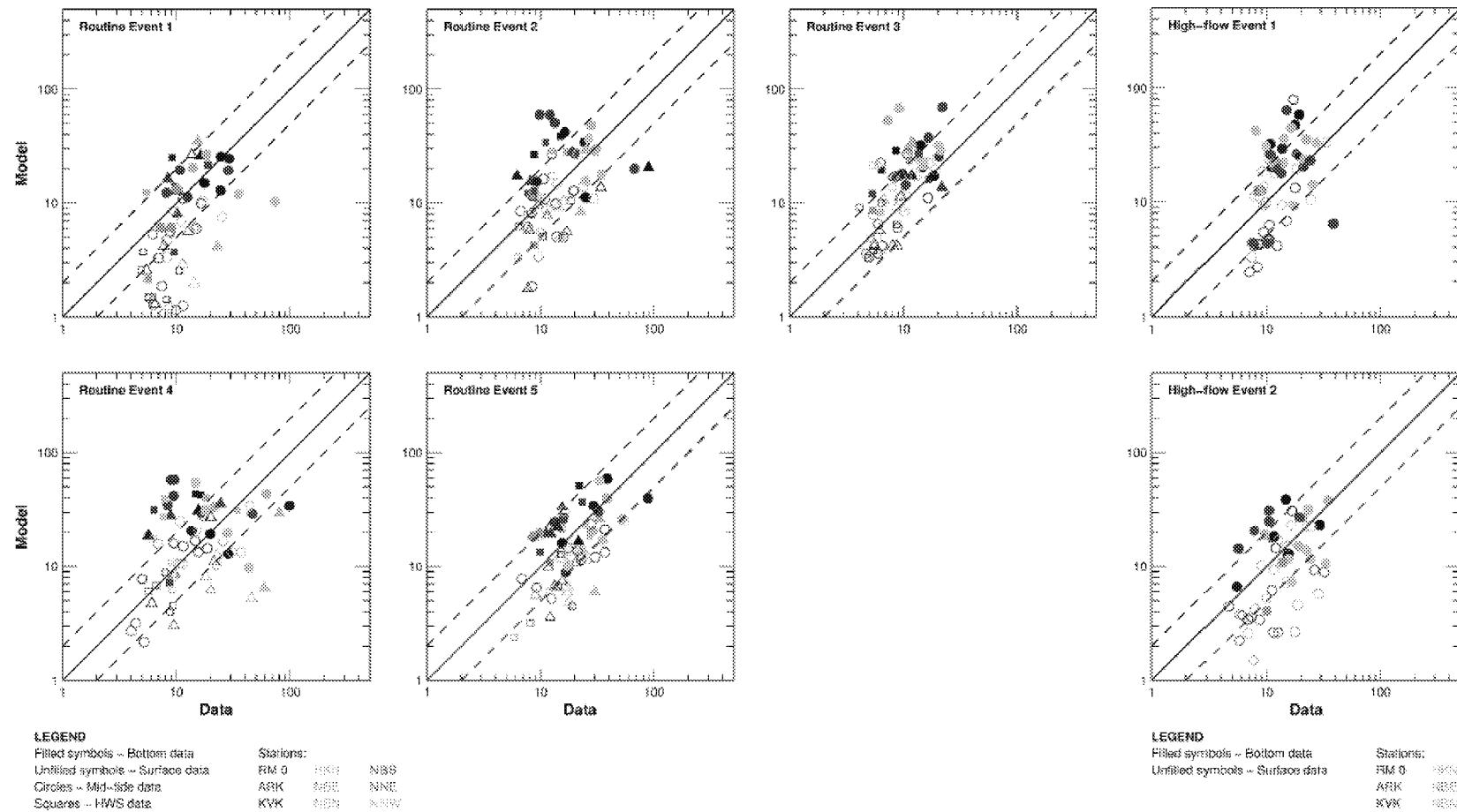


NBSA Model Performance – CWCM Sampling Locations

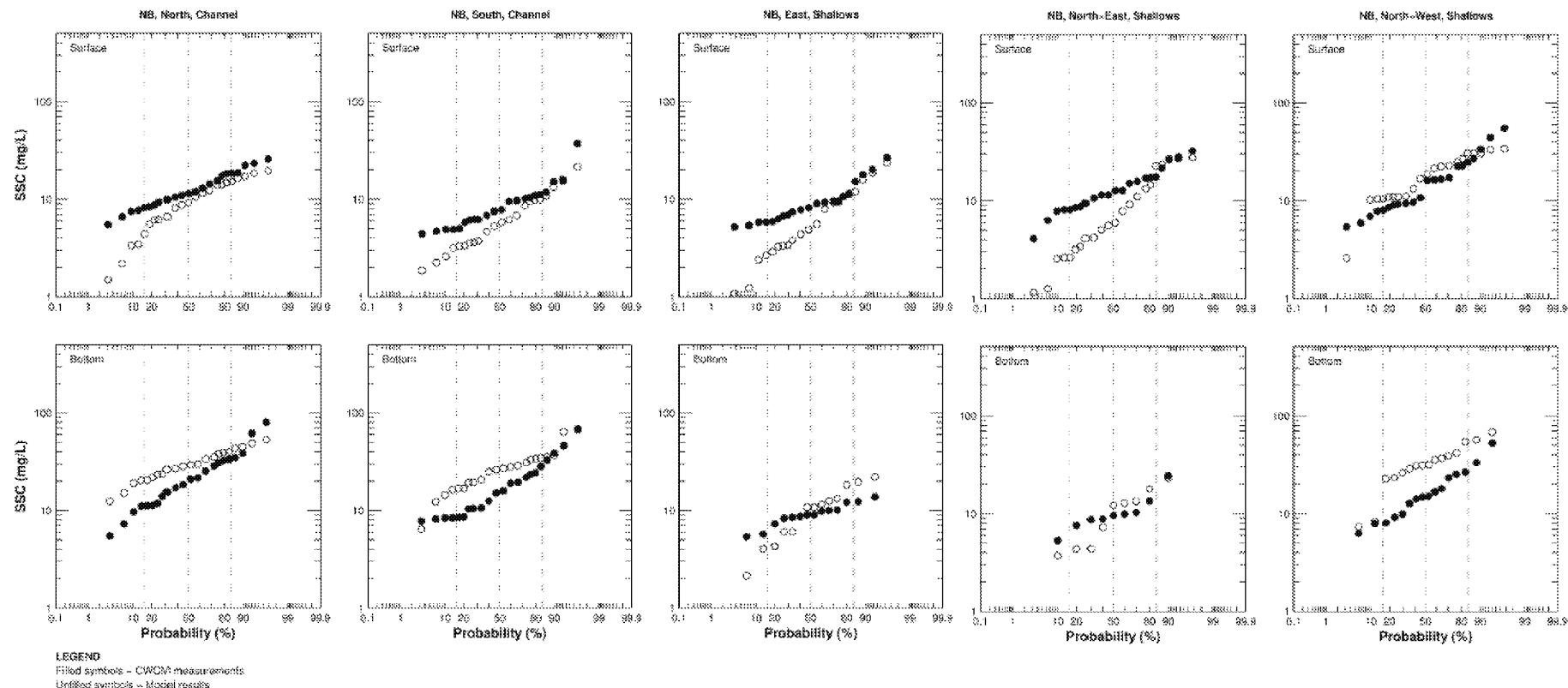
- CWCM sampling locations
 - Stations at NBSA boundaries
 - Stations within NBSA
 - * In channel
 - * On shallows



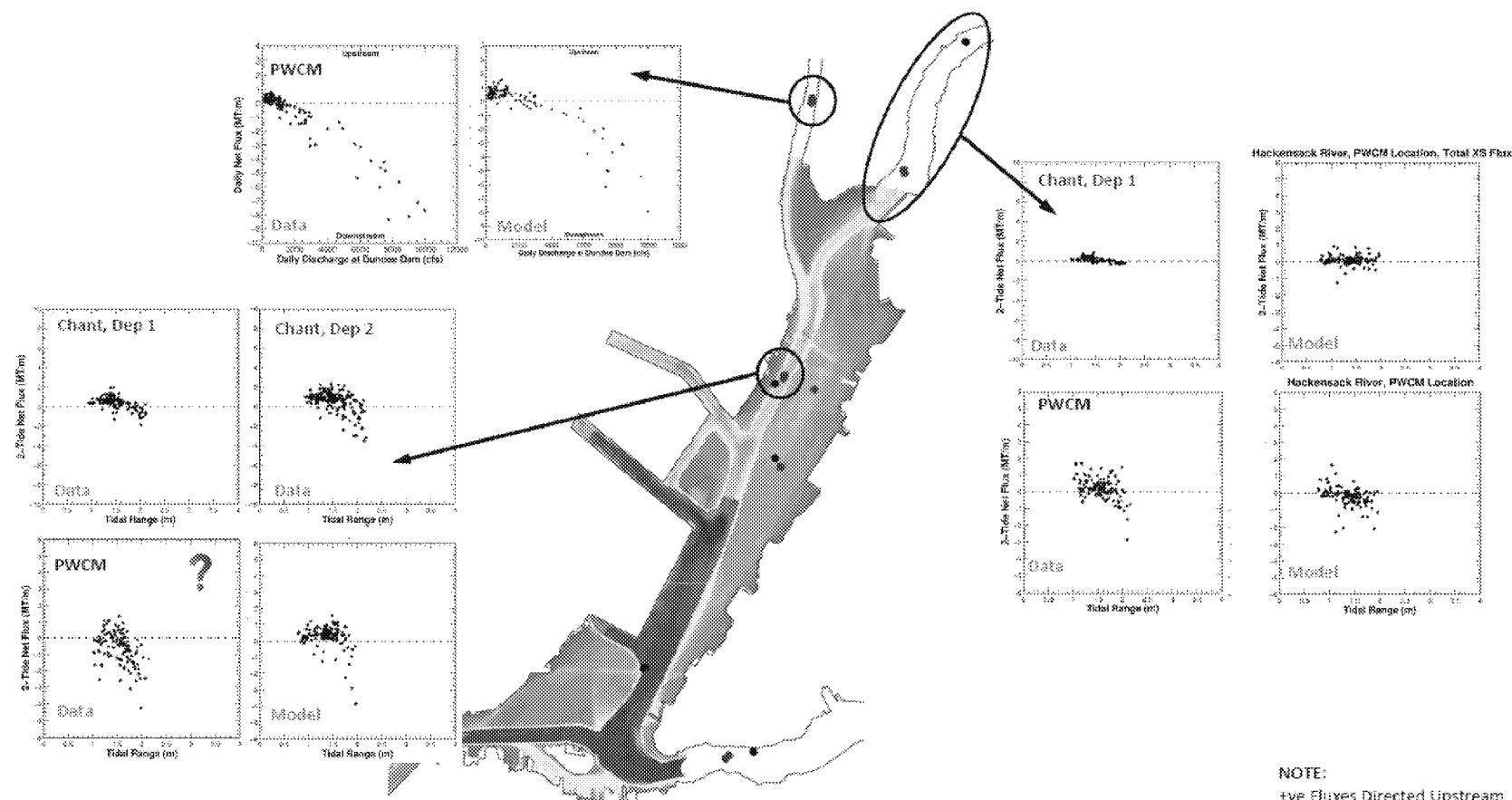
NBSA Model Performance – TSS, CWCM Data



NBSA Model Performance – Within NBSA, TSS, CWCM Data



NBSA Model Performance – TSS Fluxes

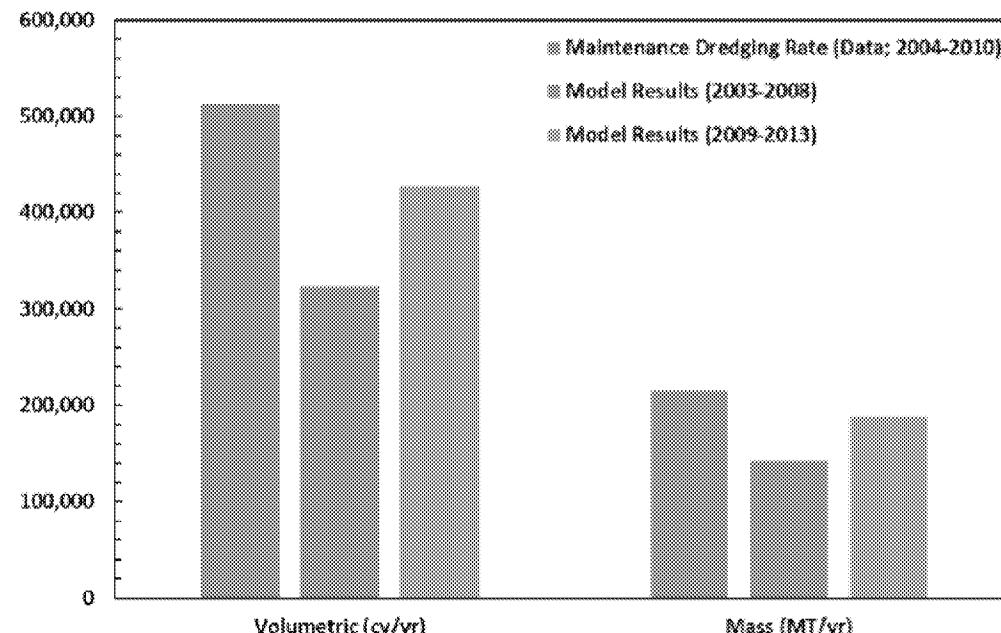


LPR/NB Modeling Program



NBSA Model Performance – Maintenance Dredging Records

- Comparison of recent maintenance dredging rates to model-calculated sedimentation rate
- Uncertainty in reported volumes (and mass)
 - Mostly based on ocean dumping records
 - Volumes based on *in situ* or disposed volume?
 - Dry density for mass based on model inputs for dry density (averaged from core data in channel/terminal areas)



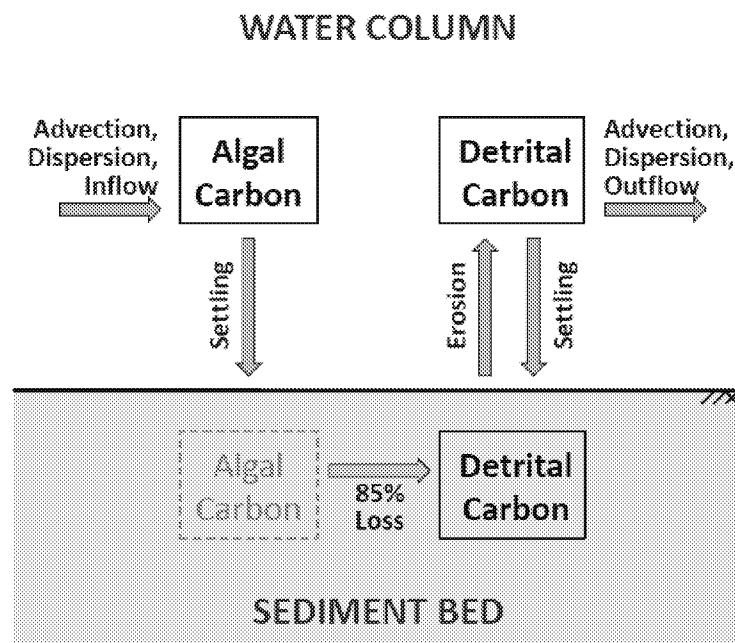
HST MODEL REVIEW SUMMARY

- CPG responded to RI comments:
- Model Inputs, Output & Code
 - March 29, 2017 – Transferred wind-wave linkage problems in a few years (identified by Moffat & Nichol)
 - May 18, 2017 - Updated files (corrected linkage)
- Based on model review to date:
 - Hydrodynamic, wind wave and sediment transport models performing reasonably
 - Calibration refinements for NBSA resulted in small improvements in calibration in LPRSA
 - Minor problem with input file for tributary inflows (Second, Third, Saddle Rivers) in final 3 years of calibration – being addressed by CPG (Moffat & Nichol)
 - HDR continuing with detailed review

ORGANIC CARBON MODEL (OC)

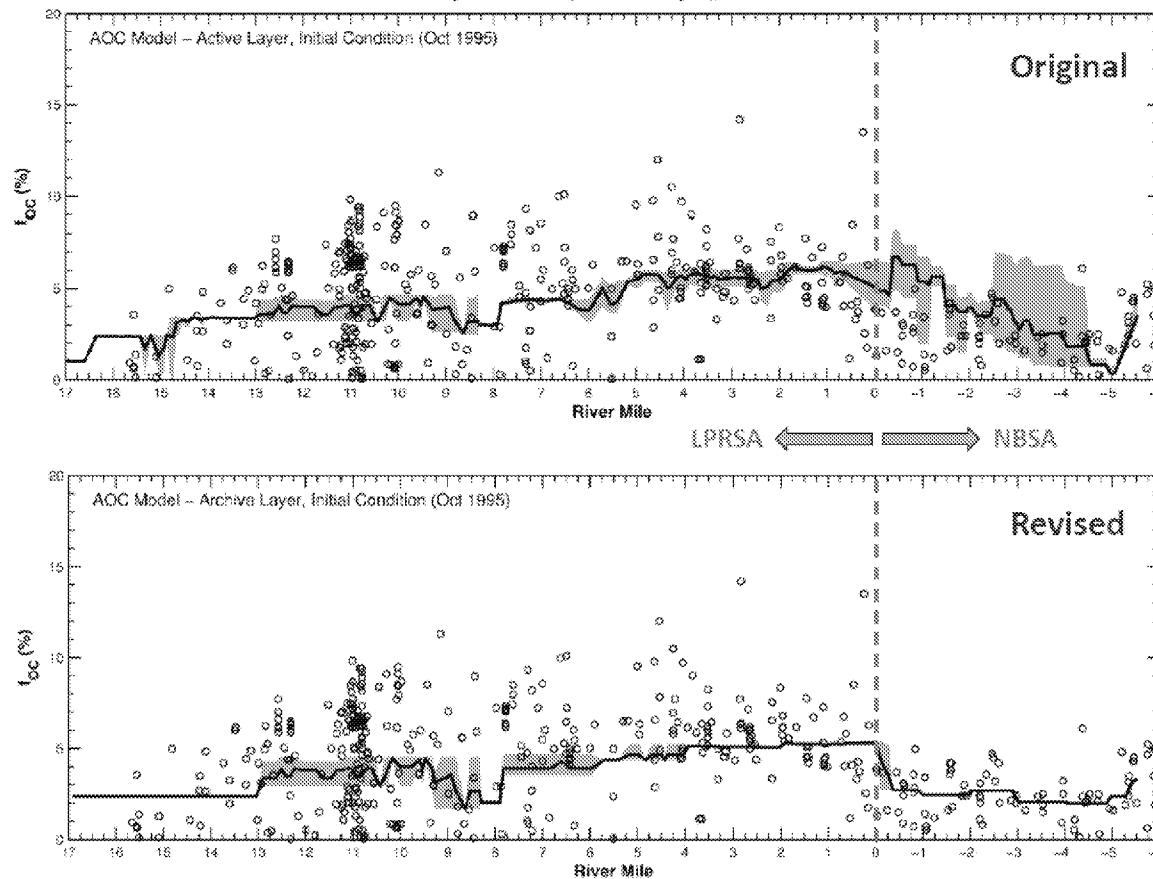
OC Model Framework

- OC model framework
 - OC transport model
- Organic carbon entering from boundaries and subject to advection and dispersion
 - Algal carbon
 - Detrital carbon
 - * Bound to cohesive sediments
- Algal carbon subject to settling in water column
- Detrital carbon subject to erosion and settling (based on ST model)
- In bed, instantaneous loss of 85% of algal carbon followed by transformation to detrital carbon
- Mass conservation for carbon in water column



Bed POC ICs – Archive Layer, Bulk Sediment f_{OC}

1–1.5 ft Depth Interval (Archive Layer), Post-2004 Data

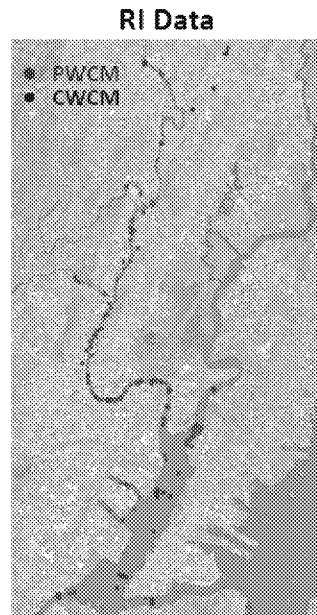
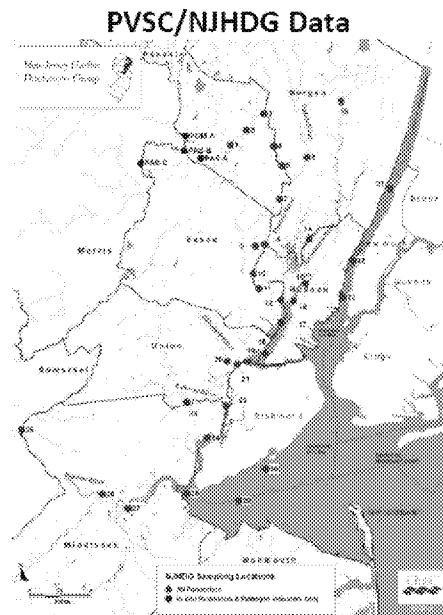


LPR/NB Modeling Program



Water Column Data Analyses

- Datasets and parameters
 - PVSC/NJHDG: DOC and Chl-a; 2003 to 2013
 - PWCM: POC, DOC, and TSS; 2009 to 2010
 - CWCM: POC, DOC, and TSS; 2011 to 2013
 - Other minor surveys, eg. Mar 16, 2010



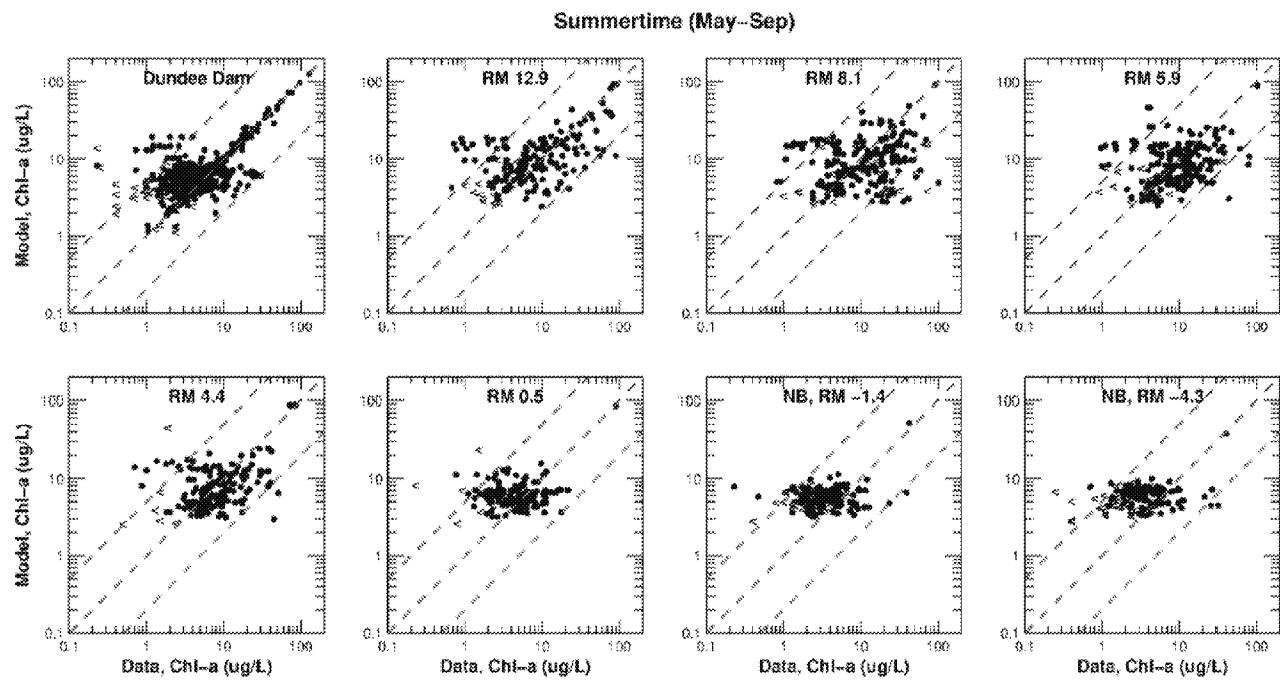
LPR/NB Modeling Program



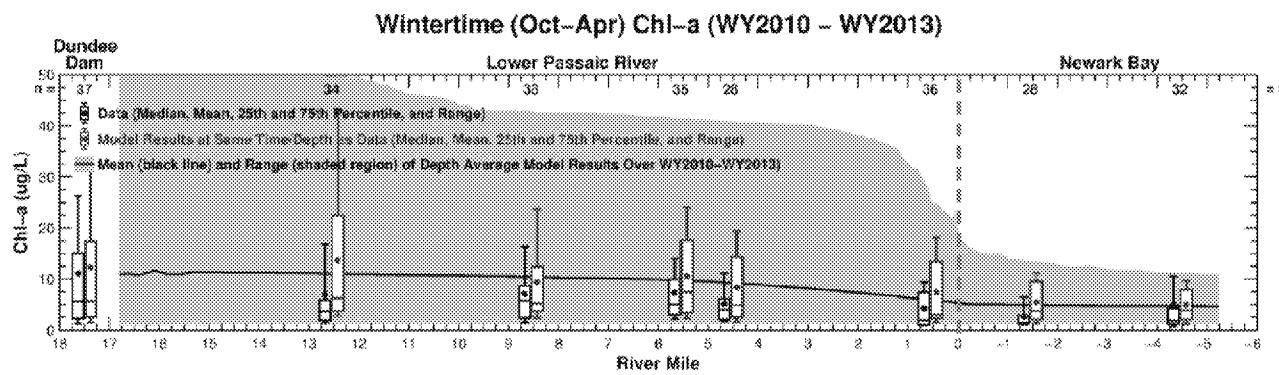
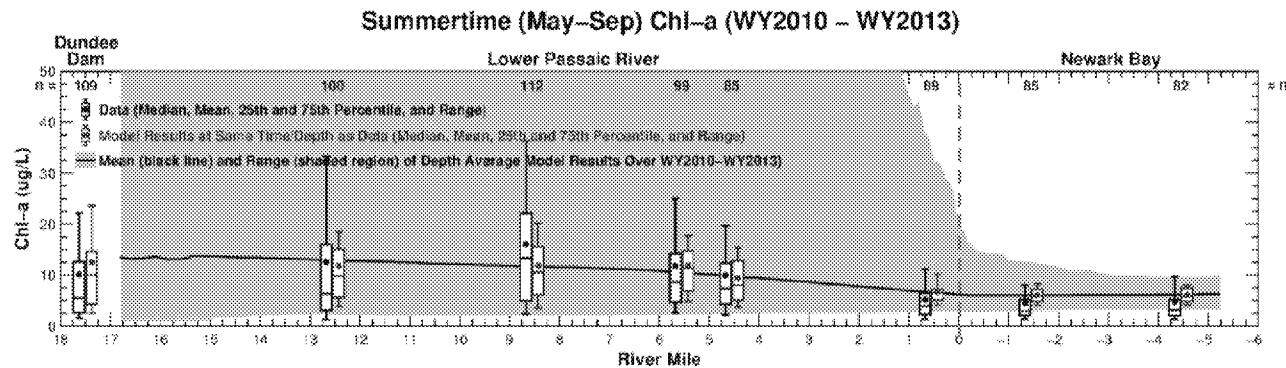
OC Model Application and Performance Assessment

- Calibration simulation – continuous simulation from WY1996-WY2013
- Model grid resolution – same as used for HD, ST, and CFT models
- No calibration or adjustment of any model parameters from draft RI version
- Calibration metrics
 - Chl-a
 - Water column POC
 - Bed f_{OC}
- Calibration datasets
 - PVSC/NJHDG
 - PWCM
 - CWCM
 - LRC, SSP, SSP2, RM 10.9, other non-RI and RI datasets
- Calibration periods
 - 2003-2013, Chl-a
 - 2009-2013, POC
 - Model results at end of 2013, bed f_{OC}

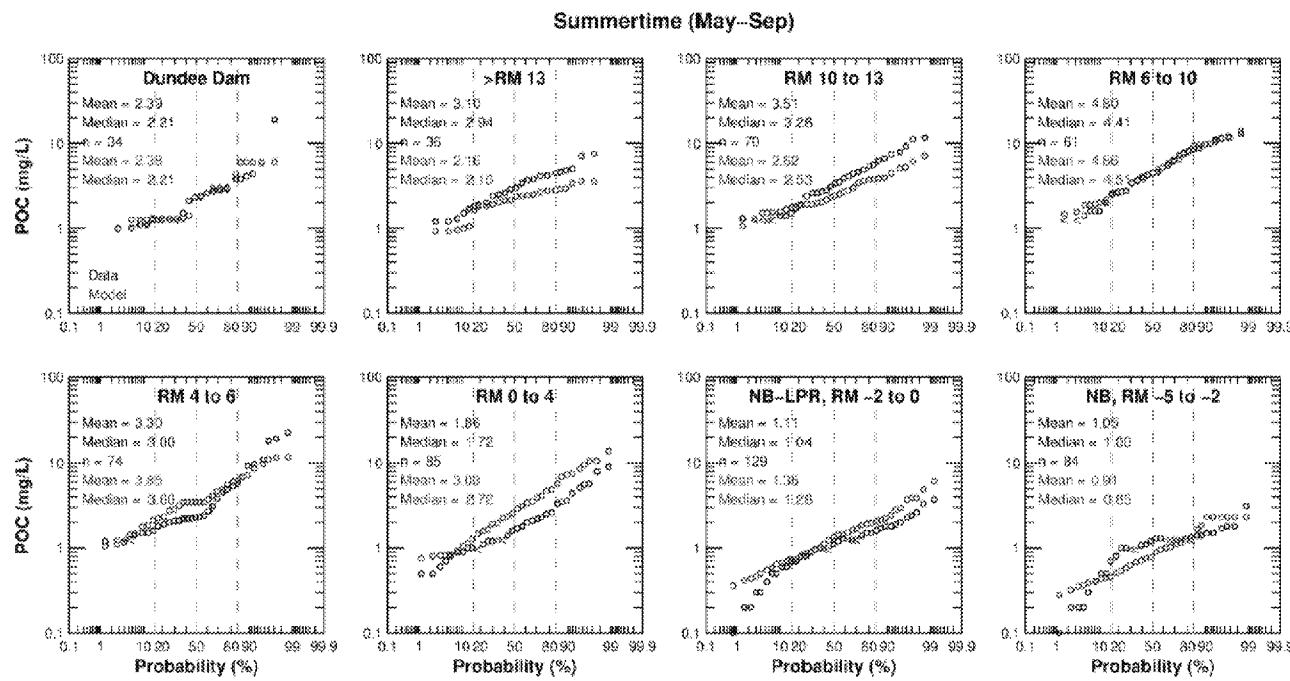
Model Performance – Chl-a



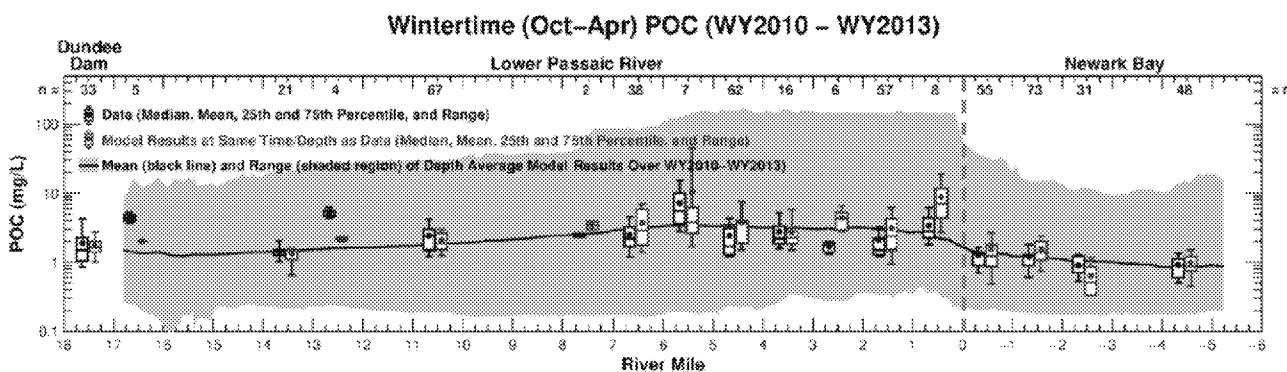
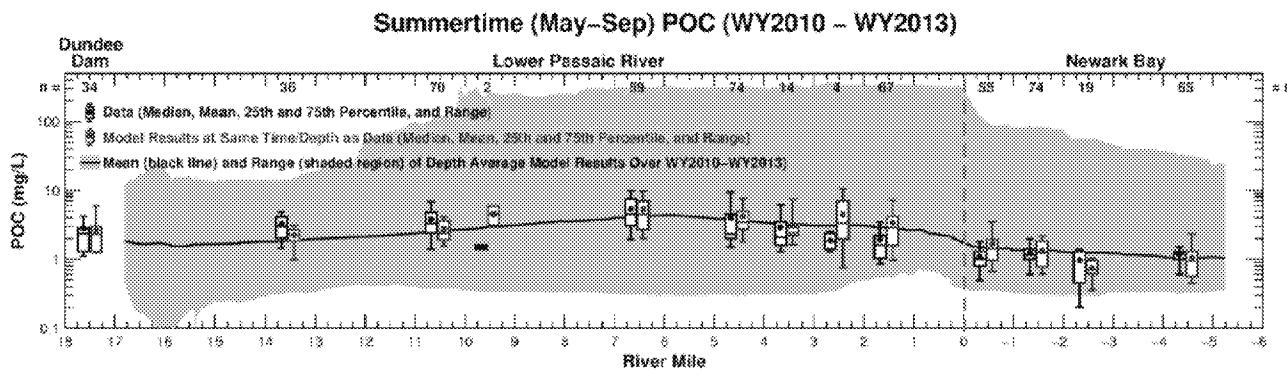
Model Performance – Chl-a (Contd.)



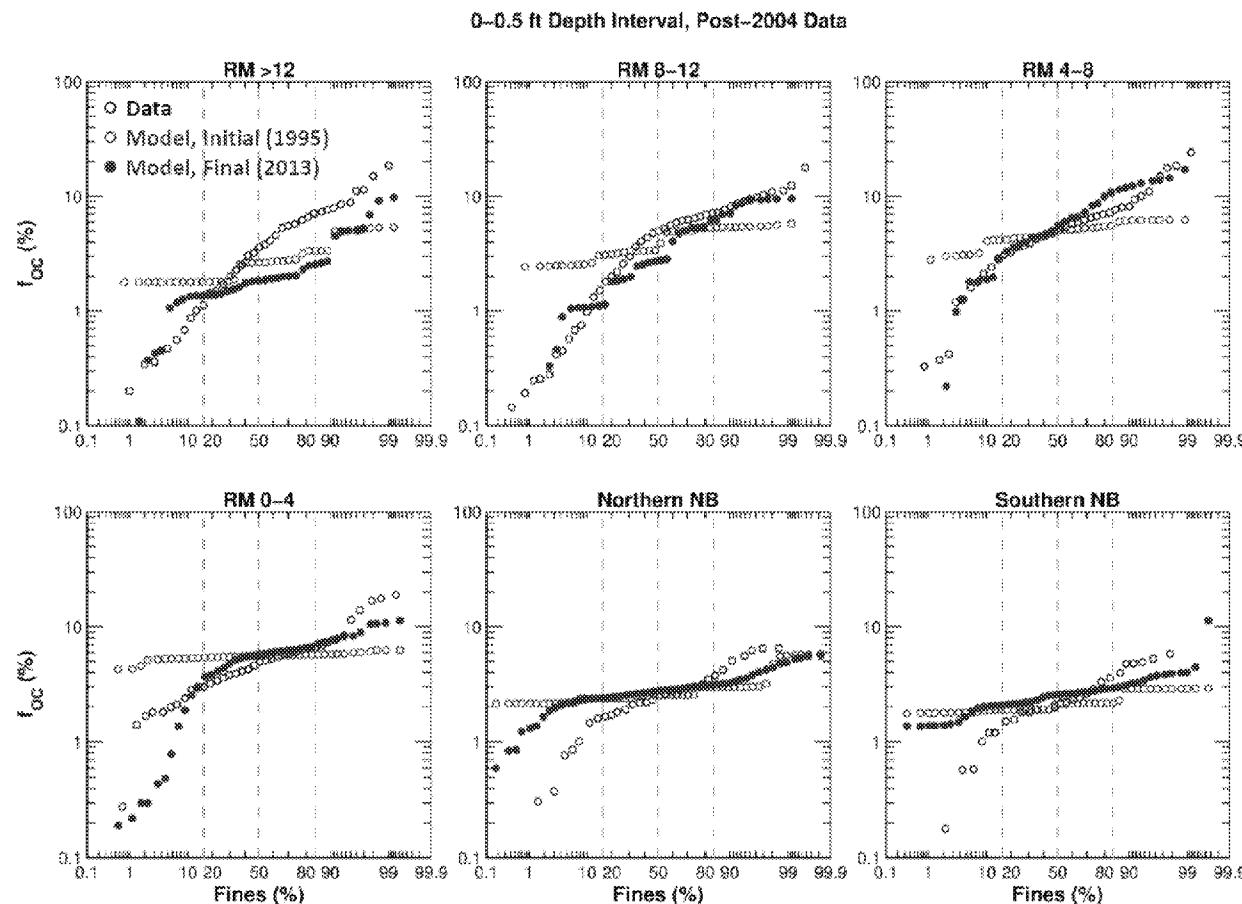
Model Performance – POC (Contd.)



Model Performance – POC (Contd.)



Model Performance – Bed f_{OC} , Active Layer



LPR/NB Modeling Program



Summary

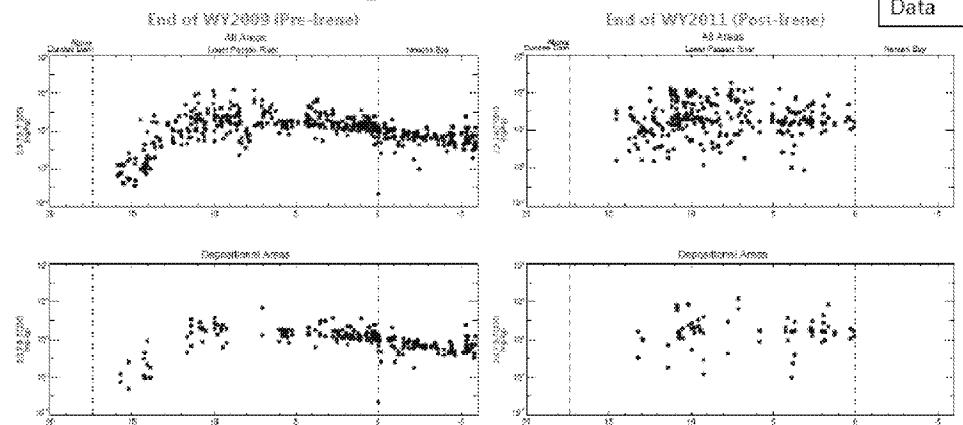
- All EPA comments regarding model setup, application, and calibration have been addressed
- Model performance evaluated over various spatial and temporal scales in bed and water column
- Model reasonably reproduces the range of parameter values, trends, and processes apparent in data
- Model performance likely subject to artifacts related to framework assumption (no carbon on sands)
- Refined OC model currently being used in CFT model development

CONTAMINANT TRANSPORT AND FATE MODEL (CFT)

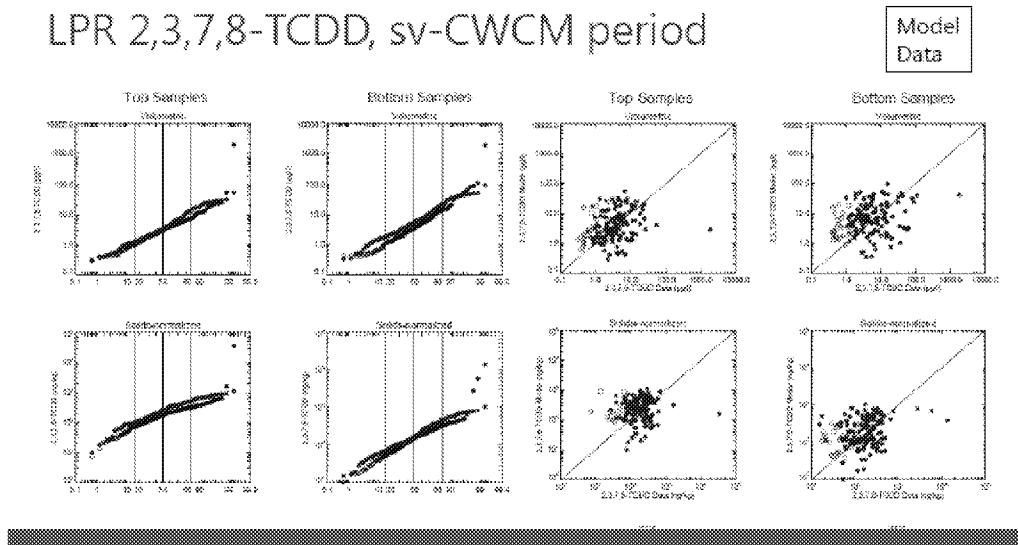
CURRENT STATUS

- Nearing Completion
- Short-term Calibration (2010-2013)
- Long-Term Calibration (1995-2009)
 - Finalizing bed parameterization – Long-term calibration (1995-2009)
- Most Recent Set of Model-Data Comparisons
 - Reach-average time series
 - » Pre-Irene (i.e. 2009) and Post-Irene (2011)
 - Cross Plots & Probability Plots
 - » 1-mile reaches (all, erosional, depositional)
 - » Surface & bottom
 - » Low & moderate/high flow
 - Spatial & Events

2,3,7,8-TCDD Long-term, Surface Sediment



LPR 2,3,7,8-TCDD, sv-CWCM period

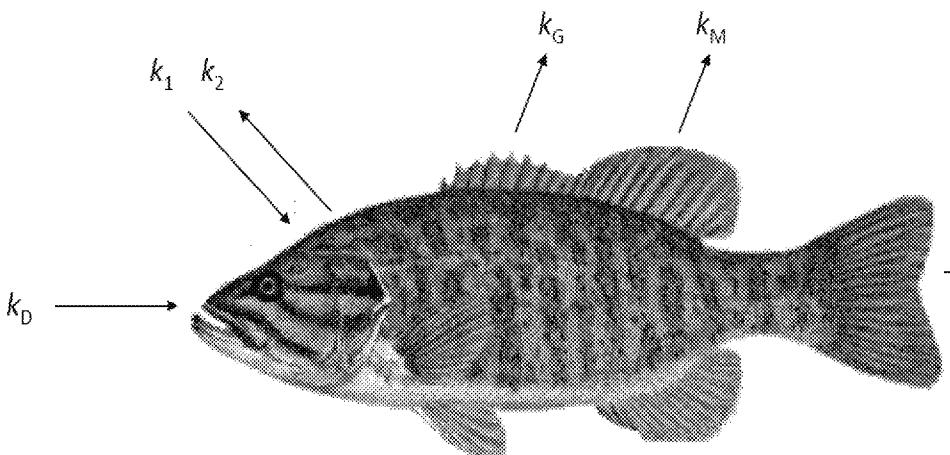


BIOACCUMULATION OR FOOD WEB MODEL (FWM)

FOOD WEB COMPARTMENTS

- Phytoplankton/algae
- Zooplankton
- Benthic invertebrate deposit feeders (DEPs)
- Benthic invertebrate detritivores (DETs)
- Benthic invertebrate carnivores/omnivores (C/Os)
- Small filter-feeding fish
- Small forage fish
- Blue crab (*Callinectes sapidus*)
- Benthic omnivorous fish – common carp (*Cyprinus carpio*)
- Benthic omnivorous/invertivorous fish – catfish (*Ictalurus spp.*)
- Invertivorous fish – white perch (*Morone americana*)
- Piscivorous fish
 - American eel (*Anguilla rostrata*)
 - Freshwater bass (*Micropterus spp.*)

Conceptual Model



Rate Coefficients

- k_1 = uptake by respiration (L/kg-day)
- k_2 = elimination by respiration (/day)
- k_D = uptake by food and water ingestion (kg/kg-day)
- k_E = elimination by excretion/egestion (/day)
- k_M = elimination by metabolism (/day)
- k_G = dilution by growth (/day)

MODEL OUTPUTS TO SUPPORT RI REPORT

- Fluxes – volume, solids, contaminants
- Seasonal variations, high flow/low flow behavior, storm surge effects
- Spatial and Temporal variations in water column contaminants
- Component Analyses

- Information Requested by Glenn Springs?